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FOREWORD

Greeting to the Ohio Academy of Science

Eighteenth Annual Meeting, Nov. 27, 1908

By

PRESIDENT EMORY W. HUNT

It gives me pleasure on behalf of Denison University to welcome this Academy. It is our hope that you may find the atmosphere of the college congenial to your spirit and purpose. You cannot meet in this building without becoming assured that the trustees and friends of Denison give hearty sympathy and support to the work of its Scientific Departments.

We believe in the truth. We believe it enough so that we are not nervous about it. We believe that the world of truth is consistent. Its various departments are not at war with each other. Apparent conflict means a faulty reading of the facts somewhere. Nothing that is true can ever obscure a faith that is real. If it is true, no matter who says it, we want to know it, and to surrender our lives to it.

Moreover, we are persuaded that every investigator and teacher needs all the light that is available. The man of truth opens wide the windows of his mind in every direction. He does not shut his mind to the light from above. The true teacher is reverent.

The teacher needs also the side-lights upon truth, the special illumination and inspiration, the enrichment of his own life, which come only from original research and independent investigation. However, the teacher must never permit himself to forget that his objective is a personality, not a "thesis." The real teacher longs to inspire in others the spirit of research, and is willing to take the trouble patiently to inculcate in them right basal methods.

One who is mentally alive enough to teach, will inevitably be extending his lines of inquiry into new territory. If he does not do this, his own mental life will stagnate and he will lose teaching power.

With this trust in the truth, and this loyalty to the light, we welcome you as fellow-seekers for truth, who are also trying to guide others into the truth.

PRE-WISCONSIN DRIFT IN THE FINGER LAKE REGION OF NEW YORK.[1]

FRANK CARNEY.

CONTENTS.

INTRODUCTION.

With old drift on Long Island,[2] in New Jersey,[3] and in northwestern Pennsylvania,[4] it is very likely that a line of old drift should connect these areas. If, however, these localities of old drift represent ice-work from separate dispersion centers, then the re-entrant angle not covered by this drift might include much of

[1] Reprinted from the *Journal of Geology*, vol. xv, No. 6, September-October, 1907.

[2] J. B. Woodworth, *New York State Museum Bulletin 48* (1901), pp. 618–70; M. L. Fuller, *American Geologist*, vol. xxxii (1903), pp. 308–12; A. C. Veatch, *Journal of Geology*, vol. xi (1903), pp. 762–76.

[3] R. D. Salisbury, Geological Survey of New Jersey, *Annual Report for 1893*, pp. 73, etc.; vol. v (1902), pp. 187–89; 751-782.

[4] F. Leverett, *Monograph XLI*, U. S. Geological Survey (1902), p. 228; L. H. Woolsey, *Beaver Folio*, No. 134 (Pennsylvania), U. S. Geological Survey (1905), p. 7.

New York state; but this supposition is hardly in harmony with accepted facts concerning the centers of ice-dispersion. Theoretical consideration, therefore, leads to the conclusion that in the Finger Lake region of New York the late Wisconsin drift sheet covers at least the ice-erosion remnants of older drift. Students of glacial geology have already tentatively presumed earlier glaciation in this region.[5]

That there has not already been reported some observed evidence of pre-Wisconsin drift in the Finger Lake region is doubtless due to one of two causes: workers may have felt that such drift should be highly weathered; or that at this distance north of the ice-margin erosion was so vigorous as to have removed the earlier drift. In all probability ice-erosion has removed most of the weathered horizon of the old drift, mingling it so thoroughly with fresh débris that it is not easily identified. In walking over the fields of the lake country one notes the presence of small bowlders which are very much weathered, bowlders that remind him of the general condition of stones in the areas of old drift; this is the most pertinent suggestion of the earlier glaciation of this region.

PRE-WISCONSIN DRIFT IN GENERAL.

The older drift sheets have been studied more thoroughly in the Mississippi basin than elsewhere; their chronological sequence is generally established on the degree of weathering exhibited. In the case of the Sub-Aftonian[6] and the Iowan,[7] the lithological content is made a discriminating feature; the absence of water-laid material is a feature usually emphasized in describing the Kansan drift,[8] whereas the blue or blue-gray color of the unweathered Illinoian is pointed out.[9] Where the formations of different sheets

[5] R. S. Tarr, *Journal of Geology*, vol. xiv (1906), pp. 18, 19; *Bulletin of the Geological Society of America*, vol. xvi (1905), p. 217; H. L. Fairchild, *ibid.*, p. 66.

[6] W. J. McGee, U. S. Geological Survey, *Eleventh Annual Report* (1891), p. 497.

[7] Chamberlin and Salisbury, *Geology*, vol. iii (1906), p. 384.

[8] *Ibid.*, p. 389.

[9] F. Leverett, *Monograph XXXVIII*, U. S. Geological Survey (1899), p. 28; *Monograph XLI* (1902), p. 272.

of drift are superposed, the distinctions may be more accurately recorded; but good sections of this imbrication are rare. Some contact sections, all from the Mississippi valley, are shown in Chamberlin and Salisbury, *Geology*, vol. iii, pp. 385–388.

Descriptions of old drift in western Pennsylvania and in New Jersey are perhaps more pertinent to the New York area. The old deposits in Pennsylvania, described by Leverett, are very stony, the pebbles usually showing water action; the bowlders are small and mostly of local origin; only a small amount of clay

FIG. 1. Southern portion of Bluff Point viewed from the east. The break or terrace in the frontal slope is a cusp which apparently correlates with Fairchild's Wayne overflow stage of glacial lake Hammondsport.

is present; there is slight evidence of bedding; the highly weathered condition of the drift, and the great amount of erosion it has suffered, are its conspicuous characteristics.[10]

The earlier drift in New Jersey is thus described: "The outer and older drift is deeply weathered from top to bottom, even where

[10] *Loc. cit.*, pp. 228, 229, 235.

it has a thickness of thirty feet, the greatest thickness it is known to possess. Its stones, so far as they are of decomposable rock, are decayed. From it most of the calcareous matter has been leached."[11] "The constitution of the drift is, in a general way, comparable to that of the younger drift. It contains materials of all grades, from huge bowlders to fine clay." "Limestone is rarely present. When the drift occurs in quantity, glaciated stones are by no means rare."[12] "It generally lacks all indication of structure, though foliation is to be seen in some of the deeper exposures." "In its constitution, and in the relations of its constituents, the drift corresponds with till."[13]

It should be noted, however, that Salisbury does not find the extramorainic drift in New Jersey uniform in the stage of weathering attained;[14] for this reason he suggests that, while most of it probably corresponds to the Kansan, it is possible that a younger pre-Wisconsin drift may be represented.[15]

Geographical factor. The above descriptions of drifts pertain to deposits more or less distant from central New York. The diversity in the stratigraphy and topography of northern North America introduces other considerations that may render these descriptions only partly applicable to other regions. Similarity of glacial deposits elsewhere may result only from identity, (*a*) in the stratigraphical terranes which furnished the débris; (*b*) in the period and conditions of weathering to which the débris was later exposed; (*c*) in the successions of ice-invasions; and (*d*) in the distance of the sections being compared from the termination of the particular sheet in question. It is evident, therefore, that in New England, New York, Pennsylvania and New Jersey specific drift-sheets may have somewhat different features than have been reported by investigators elsewhere.

TOPOGRAPHIC CONTROL OF THE EROSION AND DEPOSITION OF DRIFT.

In general. It is probable that the main dissection lines of the Finger Lake area even before the earliest glaciation were north-

[11] R. D. Salisbury, *Glacial Geology*, Geological Survey of New Jersey, vol. v (1902), p. 174.

[12] *Ibid.*, p. 188. [13] *Ibid.*, p. 757. [14] *Ibid.*, p. 769. [15] *Ibid.*, p. 782.

south valleys, the troughs of the present lakes, their tributaries; primary, secondary, and lesser, had developed a variety of transverse valleys. So in whatever direction the ice-mass moved there must have been localities, of rather limited extent, where ice-erosion was less active; also localities where the deposition of ice-débris was more pronounced. The combined effects of glacial erosion by the different invasions has not removed all the residual soil, the regolith of preglacial weathering.[16] Nor would a succeeding ice-sheet carry off all the drift deposited by a preceding invasion. Therefore it remains to inquire into the conditions most favorable to the deposition, and least favorable to the ice-erosion of former drift-sheets.

Deposition of drift. Aside from the ground moraine, the thickness and irregularity of which attest the heterogeneously distributed load which is being carried by the retreating ice, the localized deposits of débris represent in the first place a reaction of climatic factors that cannot be specifically determined; and, in the second place, the influence of topography upon the detailed outline of the ice-front. Climatic control evidently occasioned the pulsations of halt and retreat marked by the irregularly spaced belts of thickened drift; while the distribution of drift within the belts themselves is due both to local topography and to the topography of the areas passed over, in so far as these areas have contributed to the load of the ice. Furthermore, the broader outlines of these irregularly spaced belts reflect the reaction of the larger topographic features and the general direction of ice-movement from the dispersion centers; in consequence of this we have the moraines of ice-lobes. It follows, then, that no satisfactory control can at present be announced for the spacing of these belts.

Nevertheless, the influence of topography upon the detailed expression of the drift within the belt admits of closer definition. We would refer particularly to the following three conditions: (1) In a uniformly level area the ice-front would be without pro-

[16] H. L. Fairchild, *Bulletin of the Geological Society of America*, vol. xvi (1905), pp. 53–55; R. S. Tarr, *American Geologist*, vol. xxxiii (1904), p. 287, and F. Carney. The writer's unpublished notes on the Moravia (N. Y.) quadrangle afford further proof of the presence of preglacial weathered products in place.

nounced re-entrant angles; the drift would have a correspondingly even front, while it might have a very irregular surface. This type of topography is apt also to impose its characteristics upon the drift itself, as may be seen in the prairie regions. (2) In a section where the major valleys approach a position transverse to the general direction of ice-movement, the drift is found massed in these valleys, especially on their iceward sides; while in the

FIG. 2. An east-west section showing contact of the two drifts as exposed south of Dunning's Landing. The wavy, irregular line marks the upper surface of the blue till.

tributaries of these major valleys are moraine loops or dams. (3) If, however, the chief valleys approach a position parallel to the general direction of ice-movement, we find in them lateral moraines[17] blending into loops of drift in the bottoms of the valleys; while the secondary valleys may be partially clogged or buried with drift.

[17] R. S. Tarr, *Bulletin of the Geological Society of America*, vol. xvi, pp. 218, 219.

Erosion of drift. With this distribution of drift there must have been differential erosional effects produced by a second invasion of ice. Rather slight modifications would be effected under condition (1). The work of another ice-sheet passing over such an area is compressive quite as much as erosive; the more evenly the original drift is distributed, the less obstruction it offers to the progress of later ice; whereas, the weight of the overriding ice tends to compact this drift.

During the interval of deglaciation, stream-channeling, in the featureless topography of condition (1), proceeded slowly, since, to some extent at least, the streams were consequent. But with a larger lapse of time between the periods of glaciation this surface may have attained the relief of mature dissection, when it would present to the ice of the next invasion an opportunity for more effective corrasive work.

Each succeeding invasion would remove less of the previously deposited drift; it seems very probable that the resultant of several glacial invasions of such featureless topography is somewhat aggradational. And the final form given this drift depends upon the width and spacing of the moraine belts, if the ice were subject to varying relations of feeding and melting; or upon the thickness of drift deposited in an extensive sheet in case the feeding and melting factors were about balanced, the melting being slightly the stronger of the two. That the resulting forms due to the aggradational action of an ice-sheet overriding these two types of drift arrangement would not be identical seems reasonable.

The drift as described under condition (2) would suffer much less from a second invasion. The deposits in the major valleys—i.e., the valleys transverse to the direction in which the ice is moving—would be somewhat protected from erosion; the weight of the overriding ice would tend to indurate this drift. But the drift in valleys tributary to these, since they trend more in unison with the moving ice, must suffer much more from erosion. When such accumulations are rather thick, it is probable that a drumlinoid form is the resultant of degradation by a second invasion of ice, particularly in these tributary valleys.

The most marked erosional effects, however, are observed in

the old drift as distributed under condition (3). These valleys accord with the direction of ice-movement; if they open toward the approaching ice, greater obstruction is offered to its progress, hence greater erosion results; if they lead away from the feeding ice, the disturbance of the adjacent material may not be so marked. In the former case—i.e., the northward flaring valleys—the older drift, if not eroded, is apt to be deeply buried because of the intense aggradational work of the valley lobes which characterized the margin of the waning ice-sheet. In the latter case the ice-erosion is less effective; the augmented ice-front drainage has degraded, shifted, or covered with later outwash the earlier deposits. The application of this principle probably varies inversely with the size or width of the valleys.

FIG. 3. Contact of the two drifts at Crosby. The broken line marks the upper surface of the compact blue till.

But the old drift in the minor valleys of condition (3) has suffered less from ice-erosion. The stage of development of these minor valleys, and their degree of transverseness to the moving ice are important factors in controlling the extent of ice-erosion in them.

Furthermore, under all these conditions we should find more old drift preserved in areas where during either pre- or interglacial time the drainage has suffered rejuvenation. The chances of such old drift being later revealed is greater in the transverse drainage lines of condition (3).

INHERENT CHARACTERISTICS OF OLD DRIFT THUS PRESERVED.

Compactness. The obvious resistance which this old drift offers to stream- or wave-cutting is its most characteristic feature. The pressure of the overriding ice-sheet has not only rendered such drift very compact, but there should be seen, particularly where the original deposits were fine in texture, a foliation due to the pressure. Lamination also might be contemporaneous with the formation of the deposits, but in any event it would be induced by great pressure. The effect of the superincumbent weight of a second ice-sheet should be noted, where the drift has been dissected into rather vertical cliffs, in the tendency of the pebbles and bowlders to overhang.

Color. In the region under discussion ice-erosion has had, in general, favorable conditions for effectiveness. The highly weathered zone of an earlier drift-sheet would be most disturbed or eroded by another invasion of ice, except in the case where ice-erosion had fallen short of the unweathered zone. The part of this earlier sheet remaining should have its original color, or at least the color which it had just previous to being overridden. Its present color need not necessarily be fresh or untarnished, but there is strong presumptive evidence that no color alteration has occurred since the retreat of the Wisconsin ice which furnished the débris for a protective burial of this older drift.

TOPOGRAPHY OF THE FINGER LAKE REGION.

General statement. The wide, prevailingly mature, lake-bearing valleys of central New York have received critical attention from workers in many lines of geology. Less attention, however, has been given to the more mature defunct valleys generally transverse to these. It is the unusual parallelism of the former, and their marked scenic beauty resulting from the variously interrupted

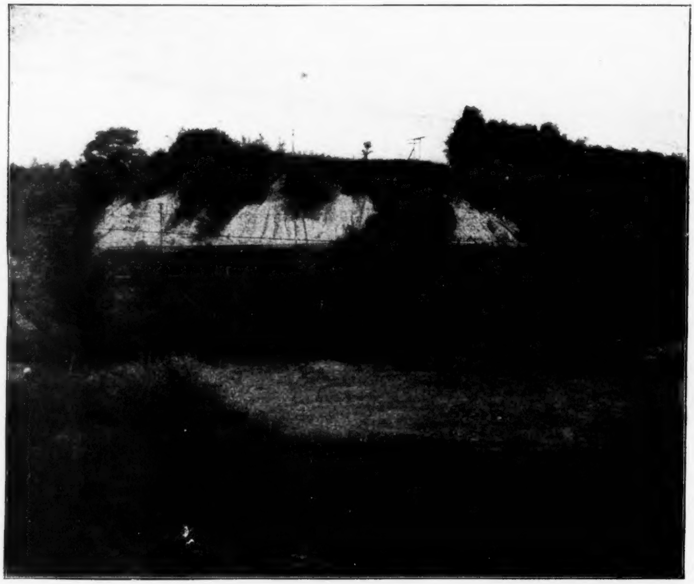


FIG. 4. The horizon of the Wisconsin drift is fairly well defined by the vegetation; the steep bare slope consists of very compact bluish till.

drainage history, that impel the comment of even the untrained observer. These long valleys opening to the north were occupied during the waning stage of the ice-sheet by valley glaciers[18] or by valley lobes which were relatively broad—a condition due to the iceward slope of the valleys.

[18] H. L. Fairchild, *American Journal of Science*, vol. vii (1899), pp. 252, 253.

Topography favors both ice-erosion and ice-stream aggradation. These conspicuous valleys, digital-like in arrangement, because of their general north-south trend, molded the basal ice of the deploying sheet into forms that expedited erosion. Furthermore, the fact that these valleys sloped toward the overriding wedges of ice facilitated the acquiring of a load which in turn augmented the erosive power of the ice up to the time when the amount of this load became so great that the basal ice lost in velocity; it then did little degradational work. In consequence of this differential erosion we find that approximately the southern thirds of these valleys are zones of ice-aggradation. Therefore, Professor Tarr's 900-foot-contour upper limit of most active erosion[19] defines a plain which dips into the Allegheny Plateau. The present attitude of this plain of erosion embodies some post-glacial deformation due to warping; but, neglecting the effects of this warping,[20] it is not likely that the plane would define a surface even parallel to its original attitude. Concerning the relation which this part of our continent bore to sea-level while the Wisconsin ice-sheet was active, we have insufficient data to warrant any but very general conclusions.

It is evident, then, that so far as the north-south valleys are concerned, exposures of the old drift are more apt to be found in a belt skirting the zone of heavy drift in the southern parts of the valleys; northward from this hypothetical belt erosion may have been very active, tending to remove the earlier deposits; southward, aggraded glacial rubbish has probably covered these deposits.

Few of the quite mature transverse valleys belonging to an interrupted but well-developed drainage cycle, above alluded to, have been described.[21] The more nearly transverse to ice-movement such valleys lie, the less ice-erosion they are subject to. Subsequent invasions of ice presumably have not removed much of the residual rock waste that escaped the earliest glaciation; nor would

[19] *Popular Science Monthly*, Vol. lxviii (1906), p. 389.

[20] G. K. Gilbert, U. S. Geological Survey, *18th Annual Report* (1896–1897). pp. 603–606; H. L. Fairchild, *Bulletin of the Geological Society of America*, Vol. x (1899), pp. 66–68.

[21] R. S. Tarr, *American Geologist*, Vol. xxxiii (1904), pp. 271–291; F. Carney, *Journal of Geography*, Vol. ii (1903), pp. 115–124.

an earlier deposit of drift suffer great erosion. Consequently valleys of this type are best fitted for the preservation of pre-Wisconsin drift. In the area covered especially by this paper two segments of such valleys, one extending eastward from the vicinity of Branchport (Penn Yan quadrangle), the other extending westward from Dresden (Ovid and Penn Yan quadrangles), have been studied.

LOCATION AND DESCRIPTION OF THE PRE-WISCONSIN DRIFT IN QUESTION.

First indication of such drift. In the area from Skaneateles to Keuka Lake the writer has often noted the highly weathered condition of smaller bowlders, both on the surface and in cuts in the drift. Later acquaintance with the older drift in Ohio has led him to give further attention to this observation. These scattered rather rotten crystallines may or may not suggest drift of different ages.

It is not likely that the first or even the second ice-invasion removed all the residual products of preglacial weathering. This much weathered material would constitute a larger part of the first than of any later drift-sheet. And from the fact that residual decay is noted beneath the Wisconsin drift[22] it follows that some preglacial weathered products have withstood several periods of ice-erosion.

Western slope of Bluff Point. This elongated ridge, drumlin-like in outline and slopes, peninsula-like in reference to the arms of the lake,[23] rises about 715 feet above the level of Keuka Lake. Its longer axis is meridional (fig. 1.) The striae below the 1100-foot contour measure S.65°–28° W. So on the western slope of the bluff the work of the ice was dragging and plucking rather than abrading. But if these striae represent only the final ice-motion in the area, then the work of the glacier may have been more vigorous

[22] H. L. Fairchild, *Bulletin of the Geological Society of America*, vol. xvi (1905), pp. 64, 65; R. S. Tarr, *American Geologist*, vol. xxxiii (1904), p. 286.

[23] James Hall, "Geology of the Fourth District," *Natural History of New York, Part IV* (1843), p. 459.

at an earlier stage. In any case, the striae, indicate that this slope was leeward at least part of the time, hence the subdued erosion.

In the veneer of drift we note a conspicuous number of very weathered stones. These constituents in many instances are rotten, going to pieces under a blow of the hammer; others show in cross-section a surface altered zone, one-quarter to one-half inch wide. Even the pitted quartzite bowlders are not rare.

Eastern slope of Bluff Point. On this opposite slope of the bluff a roadway leading northward from Dunning's Landing makes an exposure of highly weathered material just north of William T. Morris' cottage. This is the only section which suggests a concentration of rather uniformly altered drift constituents; neither the location nor the weathered condition of this exposure necessarily implies old drift.

About one-half mile south of Dunning's a recent stream channel reveals the contact of two distinct types of drift. The upper horizon is the familiar Wisconsin which here overlies a semi-indurated bluish till. This latter is fresh in comparison with the overlying Wisconsin which at this point is about 6 feet thick (fig. 2).

Northward along this slope a similar arrangement of drifts was noted in three places.

On these steep slopes heavy rains and spring thaws open new channels, cutting 10 feet to 15 feet in a few seasons. The Wisconsin drift is easily channeled, the other resists erosion more effectively. After a few seasons, however, the surface horizon weathers and covers the blue till formerly exposed.

As explained above, the direction of this valley is more nearly accordant with the direction of ice-movement; the older drift here was exposed, therefore, to more vigorous erosion. The portion of this old drift which has survived ice-erosion is the lower, unweathered parts. Thus the old drift is commonly fresher than the new.

The North Crosby exposure. On the opposite shore of the lake, a few rods up the hill from the North Crosby Landing, a recent stream course discloses a hard bluish till, which shows no evidence of structure, overlain by Wisconsin drift. This channel in places is 15 feet deep; the maximum showing of the basal drift is about

4½ feet where it forms the bed of the cut, but it is not constant, the Wisconsin sometimes forming the entire cross-section of the cut. The hardness of the blue till here is evident from the overhanging of the bowlders (fig. 3), which may be two-thirds disclosed before dropping from the face of the cut. We have not seen in this material bowlders more than a foot in diameter. The sharp angle of slope which this till maintains in comparison with that of the Wisconsin above is evidence also of the compressive force to which it has been subject.

Mixed exposures. About a mile southeast of Branchport, near the point where the old valley joins the Branchport arm of the lake, a creek trenches the recent drift, which here contains scattered masses of blue till. We noted one area at the foot of the channel wall which may be in place. The Wisconsin drift here alluded to appears to be from a lateral tongue of ice which fed into the valley, thus disturbing the older deposits.

Another area where old drift is incorporated with the new is at the end of Bluff Point (fig. 1). Here is a quantity of débris, largely local, dragged around the slope of the bluff.

Keuka Lake Outlet exposure. The most pronounced section of the bluish till may be seen along the outlet of the lake. A typical exposure is skirted by the highway and is in sight of the New York Central Railroad at Keuka Mills. Here the superjacent Wisconsin is the thinner, measuring a little less than 18 feet, while the bluish till measures nearly 30 feet. The ease with which the former weathers is demonstrated by the low angle of slope, and by the covering of vegetation; the older drift has a steep slope and no vegetation (fig. 4), and shows very slight evidence of structure.

The outlet of Keuka Lake drops 265 feet in its course of scarcely 7 miles to Seneca Lake; it consists of a rock-bound gorge alternating with amphitheater expansions, in which one or both of the rock walls are absent where the present course crosses or enters a former more mature valley. The older drift is noted particularly in these amphitheaters of the present channel. It is probable, therefore, that the Keuka basin was tributary to the Seneca basin long before the period of bluish-till glaciation.

This same relationship of drifts is noted in the erosion channels

of streams tributary to the Keuka Lake outlet. Along the lateral from the south coming in at Milo Mills, the older drift, where not very coarse, shows a tendency to lamination, the result apparently of excessive pressure. We have noted the same condition in other localities of this region.

The most persistent expression of this bluish drift is found in the Keuka outlet valley, which is transverse to the direction of ice-movement. The valley is very mature. Naturally the Wisconsin ice-sheet did less corrasive work here than in the arms of Keuka Lake.

Erosion and color. Furthermore, the line of contact of the two drifts in the exposure about Dunning's and about North Crosby gives a suggestion as to the manner and amount of the erosion. The former contact is about 65 feet above lake-level; the latter, about 90 feet. In east-west cross-section the contact line is a series of sags and swells, or anticlines and synclines, presumably parallel to the direction of ice-progress, indicating its tendency to groove or plow the subjacent surface.

The color of this old drift is strikingly blue in contrast with the adjacent yellowish Wisconsin deposits, and the color persists even in the detached masses that are seen in exposures of the recent drift. It apparently is not the result of post-Wisconsin alteration; the till has been too much protected for that, and its compactness argues against infiltering waters as the agent. The bluishness covers the bowlders and is constant in the matrix. Evidently the color antedates its erosion and burial by Wisconsin ice.

AGE OF THIS DRIFT.

The evidence presented in this paper does not warrant an opinion as to the particular pre-Wisconsin epoch of glaciation with which this drift correlates. Critical study should be given a wider area southward to the outermost moraine of the Wisconsin drift; the numerous exposures noted in the limited territory already examined suggests that other superposed sections nearer the margin may show the older drift in a weathered condition.

The freshness of the subjacent bluish till about Keuka Lake does not suggest its correlation with the highly weathered till in

New Jersey described by Salisbury. Nevertheless, this feature does not preclude identity of epochs, since the latter drift, which was never covered by a later till-sheet, has been subject to agents of disintegration during a period that has sufficed for the development of a well-advanced drainage system, the major streams having attained "levels more than 100 feet below the levels of the lowest summits on which the drift occurs."[24]

SUMMARY.

This old drift, where now exposed, with one doubtful exception, is fresh in appearance; is very compact in structure, sometimes foliated; its bowlders preserve striae; its upper surface shows erosion, presumably somewhat beyond the removal of the weathered horizon which may be the source of some of the rather rotten crystallines now mingled with the recent drift.[25]

Geological Department, Denison University, December, 1906.

[24] R. D. Salisbury, *loc cit.*, p. 759.

[25] The writer has just noted Gilbert's paper, "Bowlder-Pavement at Wilson, N. Y." (this *Journal*, vol. vi [1898], pp. 771–775). The pertinent feature of this paper is the recognition of the possibility of two till-sheets, and of the certainty of "an epoch of local till-erosion by a glacier. The epoch may be a mere episode interrupting a period of till deposition by the same glacier, or it may be a part of a stage of re-advance following a long interglacial period" (p. 774).

AN ESKER GROUP SOUTH OF DAYTON, OHIO.[1]

EARL R. SCHEFFEL.

Contents.

Introduction. This paper has for its object the discussion of an esker group[2] south of Dayton, Ohio,[3] which group constitutes a

[1] Reprinted from *The Ohio Naturalist*, vol. viii, January, 1908. Given before the Ohio Academy of Science, November, 30, 1907, at Oxford, O., representing work performed under the direction of Prof. Frank Carney as partial requirement for the Master's Degree.

[2] F. G. Clapp, *Jour. of Geol.*, vol. xii (1904), pp. 203–210.

[3] The writer's attention was first called to the group the past year under the name "Morainic Ridges," by Prof. W. B. Werthner, of Steele High School, located in the city mentioned. Professor Werthner stated that Professor August F. Foerste of the same school and himself had spent some time together in the study of this region, but that the field was still clear for investigation and publication. Professor Foerste later made practically the same statement. The writer is

part of the first or outer moraine of the Miami Lobe of the Late Wisconsin ice where it forms the east bluff of the Great Miami River south of Dayton.[4]

General Discussion of Eskers. Much question and dispute has arisen in the past concerning the terminology[5] for certain ridge-like products of glaciation, but the designation "esker" is generally applied by American geologists to lines of débris presumably aggraded by streams between walls of ice. Though the theory of deposition in sub-glacial tunnels[6] holds the greatest credence today, the en-glacial and super-glacial or various combinations of the three theories have been offered as plausible explanations in specific instance.[7] For convenience this article assumes in the beginning that the Dayton ridges are eskers, and that they were formed in sub-glacial tunnels.

Preliminary Description of Region (fig. 1). The northern end is known locally as "The Bluffs." These trend east-northeast to west-southwest about half a mile, presenting an abrupt slope considerably over one hundred feet high toward the valley of Dayton to the north. The Miami canal runs along the slope not far from its bottom, and below this at the base of the Bluffs flows the Great Miami River. The topography of this and also of the western half of the area presents a beautiful study in kames; mounds and basins[8] are abundant. The mounds or knolls frequently show a tendency toward alignment, producing ridges. The eskers indicated on the map constitute the eastern boundary

indebted to both of these gentlemen for their courtesy. He also wishes to thank his instructor Professor Carney, for going over the field with him and taking the several excellent photographs illustrating this article.

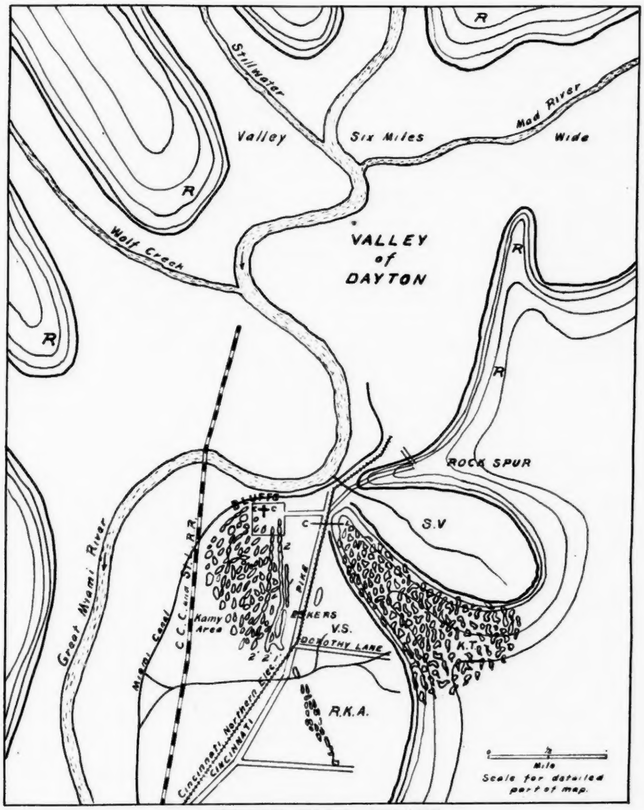
[4] F. Leverett, *Monograph XLI, U. S. Geol. Surv.* (1902), p. 355. T. C. Chamberlin, *3d Annual Report, U. S. Geol. Surv.* (1881–1882), p. 334.

[5] G. F. Wright, *The Ice Age in North America* (1891), p. 296; G. H. Stone, *Monograph XXXIV*, U. S. Geol. Surv. (1899), pp. 35, 359. W. C. Morse, *The Ohio Naturalist*, vol. vii, (1907), pp. 63–65.

[6] Chamberlin and Salisbury, *Geology*; (1906), vol. iii, pp. 373–377.

[7] W. M. Davis, *Proc. Bos. Soc. Nat. Hist.*, vol. xxv (1892), pp. 477–499; J. B. Woodworth, *Proc. Bos. Soc. Nat. Hist.*, vol. xxvi (1894), pp. 197–220; O. H. Hershey, *Am. Geol.*, vol. xix (1897), pp. 197–209, 237–253; W. O. Crosby, *Am. Geol.*, vol. xxx (1902), pp. 1–39.

[8] T. C. Chamberlin, *loc. cit.*, p. 334.



GREAT MIAMI VALLEY
FIG. 1.

This figure shows in the lower part a map of the esker and kame region. The topographic features are drawn purely diagrammatic, being intended only to give a general view of the relationship of the valleys, esker and kame area to the valley walls.

Representations of Initial Letters: *R*, Rock (outcrops); *S. V.*, Small Valley; *V. S*, Valley Segment; *K. T.*, Kamy Topography; *R. K. A.*, Ridged Kame Area; 1, 2, Eskers nos. 1, 2; 1', 2',—Knoll Endings of Eskers; *C. C.*, Calvary Cemetery; *C. L.* Southern Corporation Line of City of Dayton.

of this kame area. They overlie their base like railway embankments crossing uneven topography.[9] From the region of the Bluffs they proceed southward about a mile ending bluntly on the Miami Valley. The crest-lines are sinuous in both vertical and horizontal directions, though the general course is in almost a straight line. The esker form is at times modified by knolls, rarely by distinct gaps. The crests are narrow and the sloping sides steep, apparently taking the angle of repose normal to the débris of which they are composed. Both the eskers and the kamy topography westward rest upon a base rising above the valley of the Miami. To the southeast, across the roadway from the southern ends of the eskers the kamy topography continues for about a mile. This topography shows a curious branching and anastomosing of ridges. Though at present suggestive of kames it is quite possible that it represents modified glacial phenomena of other than kame origin. A more elaborate study of this will be made in a future paper.

Bearing on archæology. There has been a tendency in the past to explain formations of the esker type as the work of Indians or Mound Builders,[10] an error not without justification. Evidence of design in the Dayton ridges is patent to the uninitiated. They suggest an immense fortification composed of lines of earthworks; the knolls serving as lookout and signal stations, gaps for ingress and egress, and short connecting embankments as roadways from ridge to ridge. Several references are made in local histories[11] to the work of Mound Builders found in what is now Calvary Cemetery (*C. C.*, fig. 1). Of these the following quotation is the most comprehensive: "South of Dayton on a hill one hundred and sixty feet high is a fort enclosing twenty-four acres. The gateway on the south is covered in the interior by a ditch twenty feet wide and seven hundred feet long. On the northern line of embankment is a small mound from the top of which a full view of the country for a long distance up and down the river may be [illegible]

[9] Chamberlin and Salisbury, *loc. cit.*, p. 375.

[10] G. H[illegible], *loc. cit.*, p. 5[illegible].

[11] *History of Montgomery County*, Ohio [illegible] p. 215.

obtained."[12] Other isolated portions are explained similarly by residents.

Such explanations are to be doubted as few if any more than the number of Indian relics normal to this section of Ohio are found. Even admitting the archæologic suppositions, the accredited Indian work constitutes so little of the region studied, with but trifling interference to the general plan, that it may be disregarded. That no large portion can be of human construction is apparent not alone from the size of the formation, but from the evidence of assorted material in numerous cuts.

Topographic relations. Eskers differ in their relations to the topography of the area on which they rest, but according to Chamberlin and Salisbury they were probably most frequently made by streams flowing about "parallel to the direction of the ice movement."[13] The same writers also suppose the most favorable position for their formation to be "near the edge of the ice during the time of its maximum extension or retreat."[14]

It is possible that the topography of the Dayton area offers the best explanation, on a sub-glacial hypothesis, for the origin of these local eskers. Dayton lies in a large valley (fig. 1) formed by the junction of the Stillwater and Mad Rivers and Wolf Creek with the Great Miami River. The enclosing rock-bearing hills rise about 200 feet above the flood plain. The basin is filled with a varying depth of débris exceeding in places 200 feet.[15] The maximum width of the valley is about six miles. To the southward beyond the junctions the valley narrows to about one-third its greatest width. This narrowing is produced principally from the eastern side by a rock spur (fig. 1), south of which the valley again widens but not to its former size. The last rock outcrop on this spur was found on its top and several hundred yards from the end. The Bluffs extend west-southwest from this spur, the two prominences being separated by a gap which permits the egress

[12] Quotation in "History of Dayton" (1889), p. 10, from [illegible] P. Mc[illegible]s work, *The Mound Builders.*

[13] *Loc. cit.*, p. 376.

[14] *Ibid.*, p. 374.

[15] F. Leverett, *loc. cit.*, p. 361.

of drainage from a small valley (*S. V.*, fig. 1) connected with the spur. The eskers and kame area spreading southward from the Bluffs cut off a small segment of the Great Miami Valley (*V. S.*, fig. 1) lying south of the spur.

Theories of origin. In diagrammatic view (fig. 1) the valley of Dayton appears as an oblong basin with wide gaps for the entrance of the Miami River and tributaries, and one for the departure of the combined drainage. This great basin may have exerted an important influence on the waning glacial ice in controlling its movement in this area, and also in concentrating drainage that became sub-glacial.[16] That this basin and its tributaries do represent glacial drainage lines[17] is proved by the great depth and character of the débris filling. The over-riding ice would drop into the Dayton valley as in a pocket. This in the stagnant ice stages would accentuate its immobility thereby conducing to esker-forming conditions. The concentrated drainage would seek the point of easiest egress which would probably be somewhere in the gap to the south. While under great head, as doubtless the drainage would be at times of most active ice-melting, topography might to some extent be disregarded. This could explain the appearance of the ridges on the eastern side of the valley gap (possibly even superimposed over a continuation of the rock spur) rather than in the center.[18]

The close association of the eskers with kame deposits suggests that the latter were formed during the retreat of the ice after the eskers had been built in sub-glacial stream tunnels. This kame area doubtless spread originally further across the valley but has in part been removed by the meanderings of the Miami River. The abrupt face presented to the north by the Bluffs may also have the same explanation; it has already been noted that this river flows at the present time along their base. If this explanation is correct, the kame and esker topography may formerly have extended an indefinite distance northward into the Dayton valley.

[16] I. C. Russell, *Jour. of Geol.*, vol. iii (1895), p. 827. O. H. Hershey, *loc. cit.*, p. 240.

[17] F. Leverett, *loc. cit.*, Pl. II.

[18] Chamberlin and Salisbury, *loc. cit.*, p. 375.

Detailed Description of Eskers. It is unsafe to number these ridges as marking separate and distinct lines of drainage, but for convenience this method will be adopted. The easternmost will be designated no. 1 and the next, west no. 2. Other lines may exist buried beneath and masked by the kame deposits.

No. 1 (figs. 1, 2.) This may branch from no. 2. As an independent ridge it proceeds from its head (about a quarter of a mile below Calvary Cemetery) southward and almost parallel with the Cincinnati Pike to a point almost opposite Dorothy Lane (fig. 1)

FIG 2. View looking north on esker no. 1.

where it ends in a cut. The upper end of this esker though distinctly ridged is not as typically esker-like as the lower end. Intersections between no. 1 and no. 2 occur near their southern terminals. These intersections at one point form a "Y," the base of which starts from no. 1, the branches leading to no. 2. At all the intersections, four in number, the ridges rise, forming knoll-like prominences. Small bowlders about the size of cobbles are abundant on the surface. These are largely of local limestone of the same formation (Cincinnati) as that seen in the rock spur before mentioned. The exposed cut at the road shows principally

coarse gravel mingled with sand. Some of this gravel has been cemented together into a form of conglomerate by the action of carbonated water.[19] Several feet of till containing a large percentage of small bowlders overlies the gravel at this point. This exposed section at the time of the writer's first visit revealed the anticlinal stratification frequently mentioned in offering sub-glacial theories of origin. This may possibly be explained, however, by slumping of the material after the withdrawal of the ice. This cut has been extensively used by the Cincinnati Northern Electric, which runs alongside, in securing ballast for its new roadway.

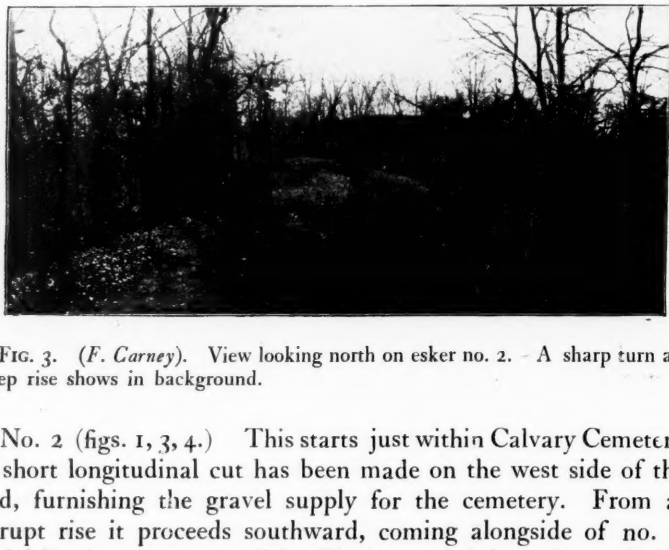


FIG. 3. (*F. Carney*). View looking north on esker no. 2. A sharp turn and steep rise shows in background.

No. 2 (figs. 1, 3, 4.) This starts just within Calvary Cemetery. A short longitudinal cut has been made on the west side of this end, furnishing the gravel supply for the cemetery. From an abrupt rise it proceeds southward, coming alongside of no. 1, and following almost parallel. To the south it branches and ends bluntly on the Miami Valley in two prominent knolls aligned with the cut of no. 1 (figs. 1, 6). Water is imponded at several points between no. 1 and no. 2. This ridge is separated the greater part of its length from the kamy area to the west by a distinct and deep trough.

[19] E. Orton, *Geol. Surv.*, of O. (1869), p. 146.

Kamy area to the west of eskers (figs. 1, 5). The kames here show a tendency toward alignment in short ridges. Sometimes they appear to radiate from a common center. Artificial cuts facing the valley show prevailingly fine material indicating by the stratification a very active play of waters.

Studies.

Proximity of eskers. The distance between the two eskers is always slight. The surface outline of this distance is usually similar to a parabola shaped trough of such a size that if one of the adjoining ridges were inverted it would approximately fit the trough. The drainage from the troughs is principally through the soil.

Height of eskers. The variation in altitude of the crest-lines and of the troughs gives varying heights at different points. No. 2 by aneroid measurement varies from 35 – to 95 + feet in height. No. 1, if measured, doubtless would give similar results.

Reticulation. The two eskers show several connecting branches. This implies a union between the lines of drainage some time during their existence. These connecting branches are so depressed in parts that tracing is difficult. Such a condition would be natural as the cross drainage would normally be so sluggish that the tunnel carrying it would probably never attain a large size. It is a question whether the two eskers represent branches from one line of drainage or are entirely independent. They may even represent a shifting of drainage lines. The lower end of no. 1 suggests by its position (fig. 1) that it may be a branch from no. 2, rather than a continuation from the head end of no. 1, as we have described it.

Knolls. Hummocks are frequent. Generally they mark the southern termini and ridge junctions. At its head end no. 2 is composed of a series of four joined together. Many theories[20] are given for the origin of such swellings. In connection with knolls other modifications of the esker type may be noted. Several buttress-like deposits were found lying against the bases of the

[20] J. B. Woodworth, *loc. cit.*, pp. 202, 203.

eskers; sometimes also a fan-like spreading of débris from a similar position was observed. These irregularities probably mark the entrance to the major line of small tributary streams, or as an alternative, the opposite condition, leakage from the major lines. The knolls at the head of no. 2 are more suggestive of tributaries than of kames.

The knoll-endings (figs. 1, 6) on the Miami Valley suggest by their alignment that they have been cut off at this point by the Miami River. Though this stream here turns to the westward, the even floor of the valley is evidence that it formerly turned eastward. The fanning of the knoll-endings into the valley where

FIG. 4. (*F. Carney*). Camera reversed from fig. 3, and view taken looking south on same esker.

they meet in an even slope is doubtless the result of slumping. Davis[21] gives a clear exposition of conditions when bodies of water are dammed by the ice-front, with the consequent phenomena of sand plains built up by esker streams. The Dayton area, however, shows no evidence of favorable conditions for the holding of ice-front waters, drainage having a perfectly free course toward the south. Streams emerging from the ice would spread out and quickly drain away. In this particular area such an outwash plain if formed would have been destroyed long ago by the erratic wanderings of the Miami.

[21] W. M. Davis, *Bull. Geol. Soc. Am.*, vol. i (1890), pp. 195–203.

Altitude of these deposits. The elevation of the area above the valley is partly due to the base upon which it rests. This is shown particularly in the kame region, the inside slopes of which are much shorter than the slopes facing the valley, a condition explainable by slumping within the area and erosion around it by the Miami as before stated.

In this connection it may be suggested that possibly gradation has greatly modified the original eskers. At the time of ice-withdrawal these forms, particularly if sub-glacial in genesis, must have been left with little or no vegetative protection. It cannot be determined how long a time was required before plant life secured a

FIG. 5 (*F. Carney*). Kame area immediately west of esker no. 2. Camera facing north. Barn rests on a long ridge of kames.

good foothold, but it is reasonable to suppose that the interval was sufficient to permit considerable weathering even on such narrow forms as eskers. With the eskers in question is it not probable that after the constituting material had assumed its natural angle of repose they may have been considerably lowered by gradational processes? Such processes would also reduce the effect of height by partially filling the trough.

Composition of eskers. A layer of bowldery till spreads over the group. This varies in thickness, sometimes being five or six feet deep. Such a deposit, of course, supports the theory of sub-glacial origin, representing as it does the melting of a body of débris-laden ice above. The gravel beneath this till in the eskers is composed of a large percentage of Ohio limestone intermingled

FIG. 6 (*F. Carney*). View looking north from Miami Valley, showing southern termini of eskers. Knoll to right belongs to esker no. 1. Two knolls next west apparently belong to esker no. 2. Westernmost knoll is a part of the kame area.

with foreign rock. Though mixed with sand it is practically free from clayey material. Cobbles of flat angular limestone are abundant on the surface. At times these cobbles intermingled with foreign bowlders of similar size literally pave the surface, a result possibly of concentration through the removal of fine material by washing. Big granite bowlders are rare.

Rock weathering. The surface bowlders show varying degrees of weathering. The limestone, not being very resistant to water action, particularly shows age. Granites sometimes appear fresh, at other times are decidedly pitted. If this irregularity is not due to their chemical composition, the inference would be that bowlders representing several different glacial periods have been mingled. In a stream-cut south of the eskers many greenstones appear. These are described by Chamberlin and Salisbury[22] as particularly abundant in sub-Aftonian drift. It may be that in these conditions evidence may be found that this area represents pre-Wisconsin glaciation and later reworking during the Wisconsin period. Such a theory would not necessarily oppose anything that has already been conjectured with regard to the history of the region.

Crest-lines. While the crest-lines are sometimes quite hummocky, the typical esker form is found in all its beauty. Straight, even-sloped sections several rods in length may be found, but the course usually is serpentine, the crest-line waving up and down and from one side to the other of a straight line. Several gaps occur, some perhaps artificial; others may be due to constrictions in the ice tunnel or various local modifying conditions. Though the general course of these eskers is straighter than in the usual type, this offers nothing inconsistent with the sub-glacial theory of origin; in fact it seems reasonable to suppose that confined streams of sufficient size to build up immense ridges of coarse material would naturally hold to a comparatively straight course.

Economic Importance.

These ridges have great economic value. The supply of gravel and sand is practically inexhaustible. The C. C. C. & St. L.

[22] *Loc. cit.*, p. 28[illegible].

steam R. R., and the Cincinnati Northern Electric run conveniently near and have made extensive cuts in securing ballast. The position of the ridges overlying the valley reduces the expense of cutting to a minimum. Tracks are run alongside and big steam scoops gather up the gravel and throw it into cars. In addition to that used by the railroads many loads are taken away in wagons. Formerly considerable sand and gravel was taken from the Bluffs by boats plying on the canal; this method of transportation is no longer operative, partly because of the decreased depth of this waterway. The group occupies something less than a square mile of surface. But little of this acreage is devoted to farming, most of it serving for pasture. There are several very desirable locations for summer homes and also opportunities for parking.

Area to the East.

The easternmost esker and the ridged relief starting on the opposite side of the roadway at its southern end block off a portion of the valley apparently belonging at one time to the Great Miami, though the level of this valley is considerably higher than the present flood plain of the Miami Valley.

Conclusion and Summary.

Eskers of Ohio have not been studied so exhaustively as those of other parts of the country, particularly of New England. Leverett, however, mentions eleven in this state, according to the tabulation by Morse,[23] in his article on the "Columbus Esker."

In describing this area and in drawing inferences the writer has endeavored to be exact and not dogmatic. Some slight errors may have been made in data; theories in any case are uncertain. It may not be possible to work out with assurance the history of the group. So many factors may have operated together or against each other that the result would appear to be without "rhyme or reason" and too complicated for unraveling. From the present day evidence, however, the following conclusions are reached with some confidence:

[23] *Loc. cit.*, p. [illegible]

1. These eskers conform in details to the type generally conceded to be of sub-glacial origin.

2. Their location was largely dependent on topography, lying as they do in a position favoring active sub-glacial drainage.

3. The heavy stratified glacial deposits other than eskers also indicate an activity of drainage beneath the ice or from its front.

4. The varying texture of the bowlders suggests a reworking of old glacial débris by the last ice-sheet.

5. The inexhaustible supply of gravel and sand offered, together with convenient location and easy access, give the area considerable economic value.

Geological Department, Denison University, November, 1907.

WAVE-CUT TERRACES IN KEUKA VALLEY, OLDER THAN THE RECESSION STAGE OF WISCONSIN ICE.[1]

FRANK CARNEY.

The tracing of the shore phenomena of the high-level lakes which characterized the recession of the Wisconsin ice sheet in New York State, particularly by Fairchild,[2] is one of the most interesting and fascinating of the contributions to glacial geology. Other geologists have performed similar tasks here and elsewhere in the basin of the Great Lakes.[3] The post-Wisconsin deformation or tilting of these ancient beaches has attracted the attention of many investigators,[4] Dr. G. K. Gilbert having given the subject special study.[5]

So far as the writer is aware, however, no study has been given to the evidence of static water bodies that presumably existed in this region in front of the advancing Wisconsin ice, nor to those which on *a priori* grounds probably existed in connection with both the retreat and advance of preceding ice-sheets. There is very

[1] Reprinted from *The American Journal of Science*, vol. xxiii, May, 1907.

[2] H. L. Fairchild, *The Amer. Journ. of Science.*, vol. vii, 1899, "Glacial Lakes Newberry, Warren and Dana in Central New York"; *Bulletin Geological Soc. Am.*, vol. x, pp. 27–68, 1899; New York State Museum, *20th Rep. of the State Geologist*, 1901, "The Iroquois Shore Line," pp. 1106–1112.

[3] G. K. Gilbert, *Geol. Survey of Ohio, Rep. of Progress*, 1870, pp. 488–90; same, vol. i, 1873, pp. 549–555, 559–560, 569–570; *Sixth Rep. of the Niagara Commission*, pp. 61–84, 1890; T. C. Chamberlin, *Geol. Survey of Wisconsin*, vol. ii, pp. 219–229, 1877; J. W. Spencer, *Bull. Geol. Soc. Am.*, vol. i, pp. 70–86, 1899; same, vol. ii, pp. 465–476, 1891; same, vol. iii, pp. 488–492, 1892; A. C. Lawson, Geological and Natural History Surv. of Minnesota, *20th Annual Rep.*, pp. 230–289, 1891; F. B. Taylor, *American Geologist*, vol. xviii, pp. 108–120, 1896; *Bull. Geol. Soc. Am.*, vol. viii, pp. 31–58, 1897; same, vol. ix, pp. 59–84, 1898; Frank Leverett, *Monograph XLI*, U. S. Geol. Survey, pp. 371–383, 1902.

[4] F. B. Taylor, *American Geologist*, vol. xiii, pp. 316–327, pp. 371–383, 1894; J. W. Spencer, *The Amer. Journ. of Science*, xli, pp. 201–211, 1891; G. K. Gilbert, *Smithsonian Report*, 1890, pp. 236–244. (For more extended bibliographies under footnotes, see R. S. Tarr, *Physical Geog. of New York State*, pp. 240–265, 1902.)

[5] G. K. Gilbert, *18th Ann. Rep.*, U. S. Geol. Survey, 1898, pp. 595–647.

slight reason for thinking that the topographic relations of the lowland area north from the Niagara escarpment and the Allegheny plateau section of central and western New York have changed much since the beginning of the Pleistocene period. Such being the case, then the duration of the pre-Wisconsin ice-dammed lakes determined the emphasis of the shore phenomena attained. Existing evidence of these old shore lines must, in most cases, stand for sharp initial development, as the vigorous Wisconsin ice with its great amount of débris tended to obliterate such minor details of pre-Wisconsin topography.

LANDWARPING.

Geologists early recognized the proof of instability in the altitude of land areas. It was further recognized that the range of vertical variation is not constant for any great horizontal distance. The Great Lakes area has already been shown to be rich in the evidence of such deformations.

That the oscillations in the altitude of northeastern North America incident to the late Wisconsin[6] stage and the succeeding stage of the Hochelagan formation[7] represent the entire range of such variations during the Pleistocene period is not necessarily true. With marine fossils in clays and sandy clays 540 to 560 feet above present sea-level,[8] and stream-cut channels at least 630 feet below present sea-level,[9] we have an interval of altitude that probably dates from the earliest ice-epoch or even earlier. The surprising erosion in the Seneca Lake Valley at Watkins, N. Y., reported by Tarr, has increased significance when connected with the deductions made by Fairchild concerning the ancient valley that leads into the Sodus Bay arm of Lake Ontario.[10] These deeply buried valleys far inland, and mature but riverless valleys seaward, suggest landwarping of like nature, but of far greater antiquity than that proved in the investigations of the Iroquois beach.

[6] DeGeer, *Proc. Boston Soc. Nat. Hist.*, vol. xxv, pp. 454–477, 1892.

[7] J. B. Woodworth, New York State Museum, *Bulletin 84*, p. 204, 1905.

[8] J. B. Woodworth, *ibid.*, pp. 215–216, 1905; *ibid.*, *Bulletin 83*, pp. 46–50, 1905.

[9] R. S. Tarr, *American Geologist*, vol. xxxiii, p. 277, 1904. Professor Tarr reports a well boring at Watkins, N. Y., 1080 feet deep without reaching rock.

[10] *Bulletin Geol. Soc. Am.*, vol. xvi, pp. 70–71 1905.

THE ALTERATION OF SHORE LINES BY LATER ICE-INVASIONS.

Partial or complete effacement of the constructional and destructional products of wave and current work in these pre-Wisconsin ice-dammed lakes would be expected. The sweep of an ice-invasion, followed by the destructional work of the slowly falling bodies of water marking the period of ice-recession, would necessarily modify, remove or cover such features as terraces in unconsolidated materials, as bars, spits, cusps, etc.; whereas the cliffs and terraces in rock would be much less altered.

The potency of ice as a factor in erosion does not make an identical appeal to all observers; this is when the sculpturing of bedrock is under consideration. So it is possible that all will consent to the general, though not complete, removal by erosion of the constructional products of lake waves and currents. As a matter of field study, however, it may as well be granted that these constructional forms have been entirely obliterated; the differentiation of a bar, or delta belonging to some pre-Wisconsin lake, from the water-laid portions of glacial drift would require an environment unusually free of other deposits. But we must grant that cliffs and terraces formed in rock would be less affected by glacial erosion.

The extent to which these cliffs might be modified by erosion would depend upon their topographic relations. Ice abrasion is more effective on the slopes opposed to ice motion; it is more effective also along the lower contours of the walls of the valleys trending with the direction of the moving ice. Hence in a series of terraces along a valley wall, the lowest one would be the most modified by glacier ice.

The beach structures of these former lakes have suffered further from wave work of more recent water bodies, especially of the high-level lakes. The degree of effacement through this agency depends upon the coincidence of the surface-planes of the two bodies of water, or upon their approximation to coincidence; if these planes intersected at a very slight angle, the vertical range of beach agents would at least partially overlap for a considerable horizontal distance; if the planes were actually coincident, then

the extent of the defacement would depend largely upon the relative duration of the two bodies of water.

Probably the most effective agency in the obliteration of these shore structures is the deposit of drift made by an ice sheet. Within the belts of thickened drift the burial must be quite complete, the chances of survival being greater with the higher beaches. But at all levels the mantle of ground moraine would in any event partially cover the weaker expressions of wave and current work. And even the pronounced cliffs and terraces might be covered in places.

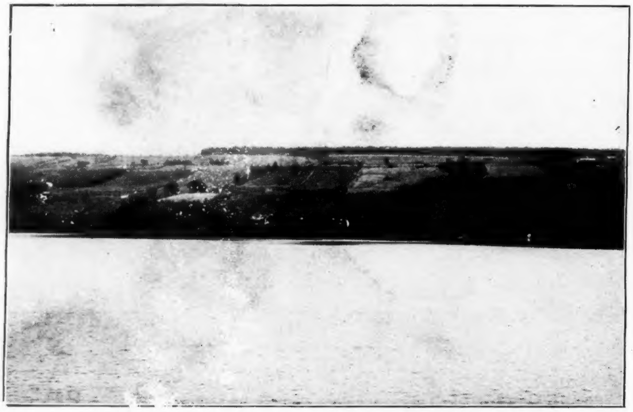


FIG. 1. View just north of Dunning's Landing. Terraces No. 2 and No. 3 show here. The steepened slope nearest the lake may represent the lowest terrace altered by ice-erosion.

Furthermore, normal subaerial weathering has tended to render less obvious such remnants of these old beaches as have survived the factors above described; the least changed would be the forms cut in the more resistant rocks.

FORMS WHICH SIMULATE WAVE-CUT TERRACES.

1. Variation in the texture of rocks is manifest in differential weathering;[11] sharp slopes simulating cliffs may be thus produced.

[11] T. L. Watson, N. Y. State Mus., *51st Ann. Rep.*, vol. i, p. 17[illegible], 1897.

The resemblance, however, leads to confusion only when the plane of the lake surface coincides with, or is parallel to and vertically within a few feet of, the hard layer or horizon of rock which marks the bench; such a ledge, in the absence of a terrace or other evidence of a beach, cannot be defined finally as a wave-cut cliff. The attitude of a bench resulting from weathering, in reference to the horizon, depends upon the dip and strike of the hard layers; because of this fact, it is not difficult to distinguish the wave-cut cliff, except when the bench is discontinuous, showing only in short segments, a condition not unusual in the coarse sandstone horizons because of the horizontal variations in texture.

2. Streams held against a slope, or against a rock salient, by ice, often form a bench somewhat simulating a wave-cut terrace and cliff.[12] Such benches have been investigated by Fairchild,[13] who shows how the banks of glacial drainage streams differ from the wave-cut cliff.[14] The latter is not so localized as the former, nor in general, so marked in development.

Considerable effort was devoted to explaining the terraces in question as the result of differential weathering. The other explanation, ice-stream work, was easily eliminated. The third interpretation, discussed in this paper, suggested itself after it became apparent that neither of the other two was pertinent.

STRATIGRAPHY OF BLUFF POINT.[15]

The succession of formations as given in Bulletin 101 of the N. Y. State Museum (which appeared after the close of the field season during which this study of wave-cut terraces was prosecuted), a report prepared by Luther, has been used by the writer in checking up his field notes on the stratigraphy of the area involved; these notes concern only the lithological aspect of the formations exposed, and since the slopes of Bluff Point are rather sharp, the rock section is almost complete.

[12] G. K. Gilbert, *Bulletin Geol. Soc. Am.*, vol. viii, p. 285, 1897.
[13] N. Y. State Mus., *22d Rep. of State Geologist*, pp. 123-130, 1902.
[14] *Ibid.*, *21st Rep. of State Geologist*, pp. 133-135, 1901.
[15] The Penn Yan Quadrangle will serve as an index map for this region.

The compact sandstone layer, referred to by Clarke and Luther, about 125 feet above the base of the Cashaqua as revealed in the Naples region,[16] appears near Keuka Park and persists southward about one and one-half miles; much of this distance it forms a prominent bench.

The next formation that might include beds for registering differential weathering effects is the Hatch shales and flags, which attain a thickness of about 300 feet.[17] Along the slopes of Bluff

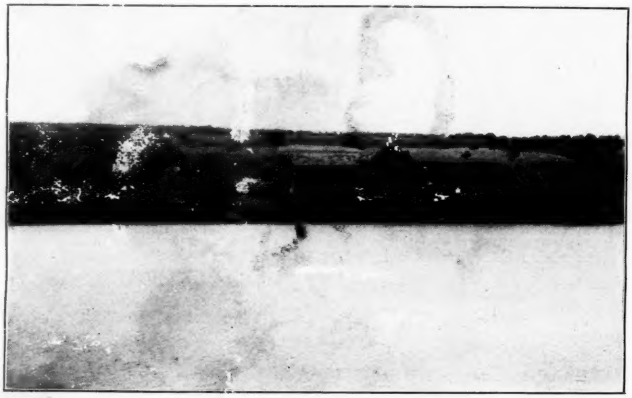


FIG. 2. View of west shore Penn Yan branch about two miles north of Dunning's Landing. Shows terrace No. 2, and what is apparently the lowest terrace altered probably by ice-erosion.

Point the sandy layers of this formation, though irregular in both horizontal and vertical distribution, are conspicuous. The greatest thickness of shale noted in any exposure is about 12 feet; the base of this horizon is 261 feet (corrected aneroid reading) above lake-level; it could not be demonstrated that this horizon of shale had much horizontal extension. Likewise the arenaceous layers, the heaviest noted being under 2 feet, do not persist horizontally.

Next in rising section is the Grimes sandstone, estimated by

[16] N. Y. State Mus., *Bulletin 63*, p. 31, 1904.
[17] D. D. Luther, N. Y. State Mus., *Bulletin 101*, p. 47, 1906.

Luther to be 75 feet thick.[18] This formation is above the terraces in question, so its characteristics do not concern us.

It appears, therefore, that there is no factor in the stratigraphy of this area to account for the marked benches. No conditions could be more favorable for registering the differential effects of weathering than the topography formed by this peninsula of rock dividing the two arms of Keuka Lake.

CLIFFS IN KEUKA VALLEY.

The succession of post-Wisconsin high level lakes that formerly occupied this region has been worked out by Fairchild. He designates the overflow channels of the principal stages, correlates the deltas, and points out some localities of wave-work.[19]

The terraces and cliffs which occasion the present paper have been studied in some detail along the flanks of Bluff Point. Terraces apparently of the same age have been noted elsewhere on the walls of Keuka valley, but have not been critically examined.

The most obvious reason for not associating these cliffs and terraces with the work already done is the fact that they are overlain and intersected by lines of Wisconsin drift. This drift is in place, and so far as observed, shows no evidence of wave-work along the planes of the terraces in question; furthermore, the drift is particularly well developed where it crosses the terraces (fig. 3).

These terraces, designated by numerals, are described in regular order ascending from present lake-level.

No. 1. This is not a clear case. For some distance southward from Keuka Park is a bench and terrace; the relation here is conspicuous enough, but the cliff consists of the hard beds in the Cashaqua already alluded to; it stands about 70 feet above the lake, but descends southward. There is, however, a persistent suggestion of a bench southward to vicinity of Dunning's, not a continuous shoulder, but a recurrence of over-steepened short slopes forming a plane that ultimately dips beneath the water.

[18] *Ibid.*, p. 49, 1906.

[19] *The Amer. Journ. of Science*, vol. vii, pp. 255-256, 258, 1899; *Bulletin Geol. Soc. Am.*, vol. x, pp. 4-41, 1899.

That the intervals of these benches are connected genetically with the more continuous shoulder and terrace to the north is not established. Furthermore, the discontinuity southward of the better developed cliff is possibly due to the vigorous ice-erosion that altered the lower horizons of the walls of the longitudinal valleys.

No. 2. This bench and terrace first shows about two and one-half miles north of Dunning's Landing. It is remarkably continuous (figs. 1, 2), and generally sharp in development. At one

FIG 3. Shows a lateral moraine which crosses the middle and highest terraces, and descends to lake level south of Ogoyago.

locality towards the north, where the eastern slope of Bluff Point blends into the northern slope, the twelve foot horizon of shale, mentioned in preceding section, was noted; here the shale is nearer the top of the bench; not much importance, however, is attached to this vertical position, further than to note that it seems to have no genetic association with the bench. The original relationship of terrace and cliff, so far as analysis of a particular cross-section is concerned, has been given much indefiniteness by the agents of degradation; whereas this relationship is still conspicuous when viewed from a distance

As a distinct feature of the slope, this terrace disappears where the valley wall becomes very steep towards the southern end of the Bluff. The till at the end of the Bluff is made up largely of local material; there is other evidence also of vigorous corrasive work by the glacier on the slopes near the end of Bluff Point.

No. 3. On the supposition that these terraces represent a body of water that fell successively to the levels indicated, terrace No. 3 is the oldest; but the difference in the degree of weathering attained, or in the sharpness of profile, is not noticeable. This terrace apparently does not extend as far north as no. 2; there is, however, some obscurity in this direction due to its disappearing beneath a wide band of drift. Furthermore its identification is not obvious quite as far south as Ogoyago; so terrace No. 3, in linear extent, falls short of the next lower terrace.

TIME PERIODS OF THESE CLIFFS.

The measure of post-Pleistocene time has been attempted through several lines of observations. The years involved in the carving of the Niagara and other gorges, in the construction of flood plains, etc., have been estimated relatively, [illegible] which do not admit of very accurate determination because of the interdependence of degradational activities, a variation in any one of which would give the units quite different values. Time-ratios of the continuity of certain phases of geological activities are less objectionable.

From a study of the extent to which erosion has effected the several sheets of till, certain ratios have been deduced using the erosion period of the Late Wisconsin drift at a time-datum. The approximate value of this ratio, which may be subject to alteration through the acquirement of new facts, for the Early Wisconsin is 2; for the Iowan, 4; for the Illinoian, 8; for the Kansan, 16.[20] The drift of the Mississippi Basin has furnished most of the data concerning these epochs of glaciation. It has already been estab-

[20] Chamberlin and Salisbury, *Geology*, vol. iii, pp. 413–421, 1906. Here is found a succinct presentation of the data on which are based the relative time-periods of the stages of the Glacial Period.

lished that the glacial period in the East was also composite;[21] but a parallelism of epochs has not been worked out.

For the purposes of the present paper, however, it is assumed that the Lake Region of New York had been glaciated previous to the Late Wisconsin stage, an hypothesis already used by others;[22] and that the interval or intervals of deglaciation were not shorter than the time-ratios held tentatively for the Mississippian area.

Illustrations of the wave-cutting work done by some of the Finger Lakes since they were lowered to their present levels are common in geological literature.[23] One who is acquainted with Seneca Lake will recall the high cliff on the east shore near Watkins, at the head of the lake; and other localities along this lake show quite as marked wave-work. Along the present shore of Keuka Lake the cliffs are not so well developed, but benches of 20 feet or more are not uncommon.

If lakes occupied these longitudinal valleys during the interims of glaciation, cliff-cutting could have proceeded to such an extent as to make survival in certain localities, at least, probable. Even the shortest inter-glacial period, on the assumption that the stages of the ice age represent oscillations of the ice from continuously ice-covered dispersion areas, was much longer than post-Wisconsin time, which has sufficed for defining exact shore lines. But terrace No. 3 has an altitude that is impossible if the body of water with which it is genetically connected discharged over any of the present cols leading into the Susquehanna area; all of the overflow channels reported for the Keuka valley are too low. It may be said, however, that many of these interlocking valleys of the St. Lawrence-Susquehanna basins, through which the waters of the high-level ice-front lakes spilled, have local characteristics which are not normal to the regular development of valleys; the conditions here alluded to will be discussed in a separate paper,

[21] R. D. Salisbury, Geol. Surv. of New Jersey, *Ann. Rep. for 1893*, pp. 73, etc.; J. B. Woodworth, N. Y. State Mus., *Bulletin 48*, pp. 618–670, 1901; F. Carney, *Journal Geology*, vol. xv (pp. 571–585), 1907.

[22] R. S. Tarr, *American Geologist*, vol. xxxiii, p. 282, 284, 1904; H. L. Fairchild, *Bulletin Geol. Soc. Am.*, vol. xvi, p. 66, 1905.

[23] *Natural Hist. of N. Y., Part IV, Geology*, p. 192, 1843; R. S. Tarr, *Elementary Geology*, p. 279, 1898; LeConte, *Elements of Geology*, p. 236, 1905.

since the problem constitutes a unit of investigation. Nevertheless there is nothing incompatible between the altitude of terrace No. 3 and a land ice-locked basin for a body of water.

DEFORMATION OF THESE OLD SHORE LINES.

From data supplied by Gilbert, it has been estimated that the post-Wisconsin deformation of the Iroquois shore line in Cayuga valley is 2.7 feet per mile.[24] Fairchild measures the warp of the Dana beach in the Seneca valley at [illegible] feet per mile.[25] In reference to the shore phenomena with which we are concerned the latter beach is more pertinent in location, and slightly less dissimilar in age. The pre-Wisconsin shore lines embody whatever tilting is shown by the post-Wisconsin water-levels, plus any earlier deformation that remained uncorrected by later land movements.

The shore lines shown in figs. 1 and 2 have obviously a greater tilt than has been reported for the post-Wisconsin beaches. No instrumental measurements of the deformation have been made, though an attempt was made by a long series of aneroid readings, checked with a bench aneroid,[26] to approximate a degree of correctness; but the line of contact between cliff and terrace is so obscured by products of weathering and glacial drift that it is impossible to get any results from this method, although the line is distinct enough when viewed from a distance. It is apparent to the eye that the highest, and presumably the oldest, terrace is the most warped.

The existence of these wave-cut cliffs, older than the Late Wisconsin stage, and their present attitude in reference to the horizon, suggest a relation of factors that have a bearing on a phase in the drainage history of the St. Lawrence-Susquehanna divide region, and on the question of ice-erosion in the Finger Lake valleys. A reference to the drainage problem was made under the preceding section. The connection with the ice-erosion problem, briefly stated, is this: These old cliffs imply an ice-dammed lake that

[24] R. S. Tarr, *Journal Geology*, vol. xii, pp. 79–80, 1904.

[25] *Bulletin Geol. Soc. Am.*, vol. x, p. 68, 1899.

[26] In the *Journal of Geology*, vol. xiv, p. 492, 1907, the writer explains this method of working aneroids in pairs.

was not ephemeral; the topography admits such a lake only when the ice-front is nearby. With such a position for the ice west of the Seneca valley, both it and the Cayuga valley were occupied by lobes from the main body of ice. Such lobes, it has been suggested,[27] would be competent to accomplish erosion; the non-existence of such lobes has been hypothecated on the absence of moraine belts, hence it is claimed that there was no erosion.[28] But since the stage of glaciation concerned antedated the Late Wisconsin which extended into Pennsylvania, the normal imbrication arrangement of drift sheets may explain the absence of the recessional moraine correlating with the ice-halt that was contemporaneous with the cliff-cutting and the over-steepening of the lower contours in the Seneca and Cayuga valleys by ice-erosion.

SUMMARY.

The cliffs described in this paper are the product of wave-work since they show no connection with such variation in stratigraphical structure as often produce benches, and since it has been found impossible to account for them in any other manner; furthermore, the presence of a cliff-cutting body of water is attested indirectly by other phases in the drainage and ice-erosion history of the region. That these shore lines are older than the recession stage of the Wisconsin (Late) ice sheet, follows from their being overlain by intersecting bands of Wisconsin drift.

Geological Department, Denison University, December, 1906.

[27] H. L. Fairchild, Ice Erosion Theory a Fallacy, *Bull. Geol. Soc. Am.*, vol. xvi, p. 58.

[28] *Ibid.*, pp. 59–60.

A FORM OF OUTWASH DRIFT.[1]

FRANK CARNEY.

The triangular area indicated in fig. 1 encloses a formation of outwash drift in an association undescribed in the literature so far as the writer is aware. This drift forms a terrace in the gradual slope to the north, the decline being about 500 feet in three and one-half miles. Approaching the area along the highway from Bluff Point postoffice (v. Penn Yan quadrangle, N. Y.), one notes the closeness of rock to the surface and the general absence of glacial drift. The slope, though gradual, is presumably the resultant of stream work, being the south wall of an old valley, and of ice-corrosion; but the marked change as one nears this triangle is due to an unusual accumulation of drift which is somewhat interlobate in origin; but the further differences between this and the typical outwash plain are so marked as to warrant a more definite description, and possibly a distinct designation.

TOPOGRAPHY OF THE REGION.

The drift under consideration lies on the north slope of Hall's peninsula,[2] designated on the Penn Yan quadrangle as Bluff Point, which attains an elevation of 700 feet above lake level. A nine-mile cross section, having a general east-west direction through the highest part of Bluff Point, resembles the letter "W," the inner legs being steepest but symmetrical to a vertical axis, while the left or west of the outer legs is the longer and has a gentler slope. The general relation of the two arms of Lake Keuka is strikingly suggestive of an originally south-flowing stream, the valley of which has been blocked by a great mass of glacial drift southwest of Hammondsport, a village at the southern end of this body of water, thus giving rise to the lake, which now has an out-

[1] Reprinted from *The American Journal of Science*, vol. xxiii, May, 1907.
[2] James Hall, Geology of the Fourth District, *Natural History of N. Y.*, Part IV, p. 459, 1843.

let past Penn Yan into the Seneca valley. Obviously this cross-section, W-like in shape, is made at the junction of the old south-flowing river and a tributary.

The general topography of the Finger Lake region, so frequently alluded to in geological articles, is a systematic assemblage of trough-like valleys opening into the Ontario lowland. Presumably the bed rock of these troughs slopes northward, as do also the divides between them. The Penn Yan quadrangle extends almost to the edge of this Ontario lowland. The Drumlin region reaches its maximum southern extension north of the Penn Yan sheet, and a few miles southwest of Geneva, which lies within the flaring walls of the Seneca valley.

ICE-FRONT AND DRIFT AS AFFECTED BY TOPOGRAPHY.

The Ontario lobe, as the ice which occupied this lowland is designated, maintained along its southern margin, during the advance and retreat of the ice sheet, valley dependencies, the development of which was directly in proportion to the depth of the troughs above alluded to. Of these troughs those of the Seneca and Cayuga valleys are the deepest and therefore probably were occupied longest by tongue-like projections of ice. Contiguous to these troughs are upland valleys which were also occupied by ice showing more or less dependence upon the lobes lying in the Seneca and Cayuga valleys. But as the general border of the ice retreated, the divide ridges separating these trough-like valleys were revealed farther and farther to the north between the converging lines of ice; and in an analogous manner the lesser divides marking and forming the valleys contiguous to the Cayuga and Seneca troughs became reëntrant angles between converging walls of ice. It is the work of two such lesser valley dependencies that is supposed to have given rise to the peculiar drift accumulation with which we are concerned.

A study of the drift about Penn Yan reveals a massive accumulation of débris which begins southward a mile or so from Milo Center and continues a mile or more north of Penn Yan. This moraine, approximately three miles wide, suggests a very slow

retreat of the ice in this region. It is evident also that this wide band of moraine represents more than the decay of the ice reaching out from the Ontario lobe into Seneca valley. It more likely is an indication of the general northwest trend of the ice-front crossing Flint, Naples, and Canandaigua valleys. When the ice

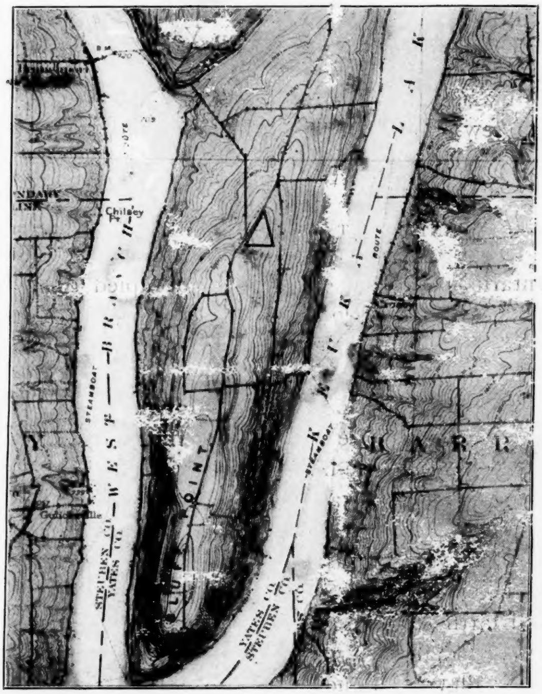


FIG. 1. A part of the Penn Yan (N. Y.) Quadrangle.

stood with a reëntrant angle approximately at Milo Center, the Seneca tongue reached many miles southward towards Watkins, while the lesser lobe in the Keuka valley was shorter. A detail of this lesser lobe evidently would give two tongues of ice, one occupying each arm of Keuka lake, with the reëntrant angle along the

north-south axis of Bluff Point, and the drift of our triangular area (fig. 1) in process of construction.

Along the margin of these valley lobes drift ridges, often widening into morainic areas, were being formed. The uniformity of such ridges as traced by Tarr on the Watkins quadrangle has suggested the characterization, "almost diagrammatic in their simplicity."[3] Each such moraine is indicative of stability in the reach of a valley lobe. Two contiguous valleys as those of Keuka and Seneca lakes would give us contemporaneously formed contouring moraines. The particular form assumed by the glacial débris at the angle of two such contiguous moraines will depend in the first place upon the northward slope of the divide; in the second place, upon the débris melted out of the ice at this particular point; and, in the third place, upon the amount of glacial drainage diverging at this point, carrying the material thus melted along the margin of the valley lobes.

From a study of these intertrough divides of the Finger Lake region, it is noted that their northward slope is gradual. The normal condition then of drift where the lateral moraines of two adjacent lobes unite reveals no special thickening. Where, however, the slope of the divide in question is steepened, and the ice immediately northward is perhaps more stagnant, or where it contains less débris, then we would anticipate a tendency toward the general removal of such débris, and the axis of the slope or divide would have less than the normal veneer of drift. On the other hand, when the axis of the northward slope is more in line with the general deployment of the ice, the chances for the accumulation of drift will certainly be enhanced. It should be noted that the northern part of the longitudinal axis of Bluff Point does trend to the east quite in unison with the direct deployment of ice from the Seneca lake lobe. This being the case then, we have the hypothetical conditions favorable to an assemblage of débris in the triangular area.

There is, however, still a further factor that favors accumulation of the drift, which is operative when the divide flattens immediately to the north, a topographic relationship due to the drainage his-

[3] *Bull. Geol. Soc. Am.*, vol. xvi, p. 218, 1905.

tory of the uplands or divide areas between these northward opening troughs. This fact taken in conjunction with the one just mentioned, that is, when the topography favors free movement from the major lobe, thus directing thitherward more active ice with this load of débris, will give us the conditions that account for the peculiar localization of the drift of the area under discussion.

DESCRIPTION OF THE DRIFT IN QUESTION.

A detailed study of this particular interlobate outwash material reveals the following facts: (1) The ice-contact face is not accentuated, that is, there is no cliff or terrace to suggest the speedy withdrawal of the ice from a position of long halt; (2) the northern part of the accumulation presents a subdued morainic surface; (3) rather numerous bowlders may be seen, some of which are the largest noted in the region. To the southward, however, this morainic topography gradually blends into a normal outwash slope. The control exercised by the falling contours of the rock slopes both east and west, is manifest in the expanding outwash when considered in connection with the moraine to which it belongs, and in the gradual falling contours of the outwash, i. e., this development of drift has something of a saddle form. Judged from the surface appearance—there is an absence of sections—the outwash material is entirely normal; there is a blending distally form coarser to finer sediments, with a few bumps suggestive of kame topography.

Proceeding southward from this area along the east slope of Bluff Point, one traces a very sharp lateral moraine marking the position of the valley tongue which occupied the Penn Yan arm of the lake contemporaneously with the building up of the outwash. This band of lateral moraine may be traced without a break until it disappears beneath the surface of the lake at a point a little south of Ogoyago. The counterpart of this band of drift on the eastern wall of the Penn Yan branch has not been traced continuously. It has been picked up, however, along the highway directly west of Warsaw, also to a point northeast of Crosby, and continuously traced where it makes the angle around the divide west of Himrods, blending then into marginal drift of the Seneca valley lobe.

But the moraine which marks the position of the valley dependency occupying the west branch of Keuka lake, at the time the outwash was developing, attained only faint expression. Its most pronounced development exists through the first mile and one-half southwest of the drift in question. From that point one cannot be certain of the outline of this valley dependency. Its form, as suggested by drift flanking the west wall of this branch of the lake, has not been investigated.

THE NORMAL OUTWASH PLAIN.

Chamberlin cites[4] references to descriptions of the general type of "glacio-fluvial aprons," variously named by geologists from 1874–1893. But a precise summary of the terminology of the deposits made by glacial waters, together with accurate distinctions on genetic and topographic principles,[5] appeared in 1902 in Salisbury's *Glacial Geology of New Jersey*, from which we quote: "Where the sub-glacial streams did not occupy sub-glacial valleys, they did not always find valleys at hand when they issued from the ice. Under such circumstances, each heavily loaded stream coming out from beneath the ice tended to develop a plain of stratified material (a sort of alluvial fan), near its point of issue. Where several such streams came out from beneath the ice near one another for a considerable period of time, their several plains, or fans, were likely to become continuous by lateral growth * * * Thus arose the type of stratified drift variously known as overwash plains, outwash plains, morainic plains and morainic aprons."[6]

This definition of an outwash plain leaves no uncertainty: genetically it results where there is a lack of alignment between sub-glacial valleys and sub-glacial loaded streams: topographically these streams should flow out upon a plain where their individual fans may coalesce. It is also evident, as Salisbury states elsewhere,

[4] Glacial Phenomena of North America, in Geikie's *The Great Ice Age*, footnote p. 751, 1894.

[5] Brief descriptions are also given in Chamberlin and Salisbury, *Geology*, vol. i, p. 306; vol. iii, p. 372, 1906.

[6] *Geological Survey of New Jersey*, vol. v, pp. 128–129, 1902.

that the degree of development of this drift-form varies with the time the ice stands at a given halt.

Woodworth alludes[7] to a washed drift which confronts the terminal moraine on Long Island; this formation, as described, is a normal outwash plain.

In his description of the drift in southern Wisconsin, Alden[8] describes an "outwash apron" which constitutes a portion of the deposits in the interlobate angle between the Lake Michigan Glacier and the Delavan lobe; his usage of the term outwash elsewhere in the paper is also in accord with the standard of definition.

In applying this definition to the localization of drift referred to on the north slope of Bluff Point, we note the following facts: (1) the absence of an initial plain, (2) the probable absence of a strong sub-glacial stream, (3) a constancy in the position of adjacent ice-lobes which built up lateral moraines, (4) a synchronous accumulation of débris in the reëntrant ice-angle, (5) diverging slopes to the south that insured rather active drainage away from this angle, and (6) a single alluvial fan-like body of washed drift blending northward into moraine.

The normal outwash plain is an assemblage of such alluvial fan-like units. The drift in question is quite identical with an outwash plain in structure, but different from it in degree of development and in topographic environment; ignoring the latter discrepancy, we may say it is a very subdued form of outwash plain that represents a constant position of the ice at the junction of two rather small valley dependencies.

Since Bluff Point is a not uncommon type of topography in the Finger Lake region, and since the writer has mapped on the Moravia quadrangle similar deposits of drift, he suggests, as a designation for such deposits, the term *inter-lobule* (or inter-tongue) *fan*.

Geological Department, Denison University, January, 1907.

[7] N. Y. State Mus. *Bulletin 84*, p. 90, 1905.
[8] Professional Paper, No. 34, *U. S. Geol. Surv.*, pp. 31–32, 1904.

STATE GEOLOGICAL SURVEYS AND PRACTICAL GEOGRAPHY.[1]

FRANK CARNEY.

The expression "practical geography," as used in this paper, implies, not essentially the utilitarian or economic phase of the subject, but the rational as opposed to the idealistic, the possible as opposed to the highly improbable or impossible. What we would accomplish in the way of right geography, and what, as a matter of fact, we are able to accomplish in the near future, are disproportionate quantities. But we do not desire the idealist to become less active; he is the standard-bearer, and when at some future time this country shall have attained the position in geography even now reached in England, we may grant that the man who always advocated the very best did more than half the work. In the meantime, it may not be futile to point out some lines of activity possible for Geological Surveys, organizations already well established and sustained in many of the States. Not only these organizations, but many others, both State and national, are constantly producing much matter that is strictly geographic, but which for purposes of geography is unused and will continue useless till properly correlated. The correlation of this material, and the accomplishment of a few other suggestions, appear to the writer practicable at the present time.

No one would underestimate the progress being made in this country in geography. The encouraging conditions furnish an incentive to hasten much better conditions. In our colleges and universities are a number of men employed solely for giving instruction in geography, and other institutions are considering the establishment of chairs. Even in secondary schools the physiographic side of geography, at least, is receiving more attention. The

[1] Written for the Chicago Meeting, 1907, of the Association of American Geographers. Reprinted from the *Bulletin American Geographical Society*, vol. xl, September, 1908.

organization of local geographic societies is another evidence of progress.

Of the various agencies through which further and more prompt progress may be effected, the Geological Surveys seem the most worth while considering. If by some necromancy we might at once bestow upon all individuals who are now giving instruction in geography a good training, making them reasonably well-equipped geographers, even such proficiency as domestic institutions can give, we would look no further. For the trained progressive teacher the innovations outlined in this paper have no personal application. In the following paragraphs I briefly consider six ways in which the Surveys might further the interests of geography:

Publications for teachers. The publications of our State Surveys contain much that is useful to the secondary school teacher; this is especially true of the economic reports, though there is an objection common to nearly all these publications; they are prepared for the class of critical and informed readers represented by the authors of the reports. No one would suggest that in this respect Surveys should deviate from the present method; such reports must not only be abreast of their phase of the science, but should also make contribution to it.

Nevertheless, it is evident to all that reports of this type can not be of greatest benefit to the average teacher of geography, and it is this teacher with whom we would labor in advancing scientific geography. To this end might not our Surveys prepare special and supplementary reports specifically for teachers? If these teachers as a class were readers of the geographical journals, the desired object might be partially accomplished; but we know they are not; furthermore, publications prepared by their own State for them in particular would make a more certain appeal. The publications I have in mind should be of two types:

a. As illustrating the class of special reports, one of these should aim at instilling a better concept of geography as a science. There is no lack of general books of method in geography, but we need terse treatments of the basal principles that should govern instruction in regional and systematic geography, emphasizing

the interrelation between the organic and inorganic parts of the subject, and impressing the necessity of a strict terminology. While in a few text-books some or all of these ideas may be exemplified, they are not given the prominence that insures an appreciation of their importance.

b. Supplementary reports summarizing for teaching purposes the more extended publications would be of great aid to the schools. For example: In recent years several States have issued extensive studies on their clays and clay industries. In nearly every case these were prepared by specialists; they contain much that is purely technical, besides facts that contribute to human relations; the facts bearing on geography admit of correlation, affording in particular an opportunity to emphasize the organic.

Some States have issued reports on one or another phase of physiography; others are engaged on more extensive physiographic studies. These contemplated publications may be strictly physiographic, embodying only the inorganic, in which case they will disregard half their scope for usefulness in the schools.

Type sets of topographic sheets. The laboratory manuals in physiography leave no occasion for reference to this topic, so far as classes in that subject are concerned. It is seldom, however, that we find topographic sheets used with classes in elementary geography. These younger pupils, consequently, do not get any conception of the map representation of relief. For their teachers, for the classes, and for older students as well, it would be a great service if Surveys were to provide at a minimum cost mounted sheets illustrating types of topography; so far as is possible, the sheets should be selected from the State concerned. Concise, lucid explanations should accompany the maps.

I am aware that teachers and school boards may secure these maps directly from Washington. But the sheets are not extensively used even in high schools. Their use would become more general if some organization of the State were to take an active interest in seeing that the proper sheets are selected, that these are made more durable by mounting, that their import is to some extent particularized upon, and that the subject of using such maps is brought directly to the attention of the parties who should use them.

The need of good maps in the schools was cogently amplified before this Association one year ago.[2] The best maps of home areas available are those issued by the U. S. Geological Survey; the more extensively they are used, the less will be the demand for mediocre maps.

Industrial activities. The State supplements of many school geographies usually give special attention to industrial activities; often maps are used in showing the distribution of areas of certain natural products, of the several lines of manufacturing, or particular phases of agriculture, etc. Some of this information is rendered obsolete or incomplete in a very few years; other data, usually illustrating the organic part of geography, appear, so that no matter how satisfactorily these phases of geography were treated in the original edition of the supplement they are shortly out of date. Two or three years often witness marked changes in the activities of many localities. The fact that there has been a change is not so important in geography as the reason for the change. It is mainly in the industrial lines that innovations arise. The publishers of State supplements can not be expected to investigate and announce these activities with the promptness and thoroughness desired. State Geological Surveys can do this; furthermore, their efforts are not constrained by mercenary interests as with competing publishers.

Field work. Some years ago the New York Survey published a *Guide to Excursions in the Fossiliferous Rocks of New York State.* This little bulletin is a type of publication that other Surveys might adopt, greatly to the advantage of geography. While the schools of each region must depend largely on the immediate locality for illustrative field work, at the same time each State possesses some features, valuable for study but localized, which should be generally known.

A thickly populated part of a State suggests several lines of investigation which a Survey can treat without in the least discouraging the initiative of local teachers. It is seldom that a city is so completely self-developed that a study of its factories, etc., does not at once lead into relationships of environment, active

[2] Cyrus C. Adams, *Bull. Am. Geog. Soc.*, vol. xxxix, p. 6, 1907.

and passive. The tracing of these relationships may be a matter of considerable study, but of sufficient importance to deserve the attention; the explanatory treatment thus given a particular phase of a city's activity visited by a class is good geography.

The school museum. The school museum as an auxiliary in teaching geography is of recognized value. The large permanent museums of certain cities and of some institutions may be of inestimable aid locally, but it is a fact that such collections seldom make an appeal commensurate with their intrinsic worth, save to a few investigators or advanced students. The completeness of such museums is both an advantage and a disadvantage. It is a question whether the circulating school museum as managed in the city of Chicago is not of greater advantage for the purpose designed. The plan brings the material right into the classroom where there are no distractions arising from strangeness and from the multiplicity of objects, as is the case when the class is taken to a museum.

The assembling and management of circulating museums might be undertaken by State Surveys. Additional appropriation should be procured to start the work; if not, increased appropriations will surely come after an exemplification of its value to the schools of the State. Exchange of material between State Surveys would be the normal method of augmenting collections, particularly of natural resources. Thus rocks, ores, minerals, fossils, and illustrations of particular phenomena, as glacial scouring, and marine grinding of given areas, would be added to the collections of other States. The museums of State colleges and universities should be the clearing-houses for this material.

A participatory method might be instituted by which school boards would pay transportation charges on the collections needed. Furthermore, the schools themselves, in localities where desirable material is to be had, might be utilized in collecting for the State, at the same time encouraging the schools to arrange permanent collections.

Manufactured products, so far as is practicable, should have a large place in these collections. Every such product is either a response to a particular environment, or a less immediate and direct but no less important fact of organic geography.

Bibliographies and digests. The quantity of matter, primarily or incidentally of geographic value, issued by both government and private presses is so great that even the teacher who is giving his entire time to this study depends to some extent on the reviews and digests appearing in journals, and in bulletins of geographical societies. That the instructor who is dividing his time with other subjects can not keep abreast in geography is apparent; furthermore, it is the exception if this instructor, when he enters upon his work, is broadly acquainted with the literature. For this reason it seems advisable to place in his way the means of strengthening his preparation, and of keeping up to date. Periodical bibliographies and reviews of the recent books and articles would stimulate this activity and insure progressiveness. Surveys could exercise a selective treatment in the preparation of such bibliographies and subjects for digesting, thus eliminating the features less pertinent to the teachers and schools of their States.

CONCLUSION.

To accomplish much of this means that Surveys should employ geographers, or the best trained men that may be secured. Where this is not feasible, the coöperation and part-time assistance of men in teaching positions would be of advantage.

The outlook is encouraging, particularly where Surveys are broadening their scope by giving attention to industrial and economic activities, and by directing investigation in phases of natural history. Regional geography is thus intensified, a work which should precede a well-founded systematic geography, because a satisfactory system presupposes a consideration of a high percentage of the facts which the system would compass.

Even the little that is being done by the least affluent of our Surveys furnishes data and opportunity for advancing better methods in geography. All that is needed is an amplification of work in few lines; an emphasis wherever the schools may be reached, both in instructing and inspiring the teachers and by supplementing the outfit of the class-room; and a correlation of data produced by the Survey, and, to as great an extent as is practicable, by other similar organizations.